Basin-scale assessment of transport of water and agricultural chemicals through the unsaturated zone

Rick Webb, Randy Bayless, Tracy Hancock, Chuck Fisher, Tom Nolan, Rick Healy, Jack Barbash, Josh Linard, and Mike Wieczorek

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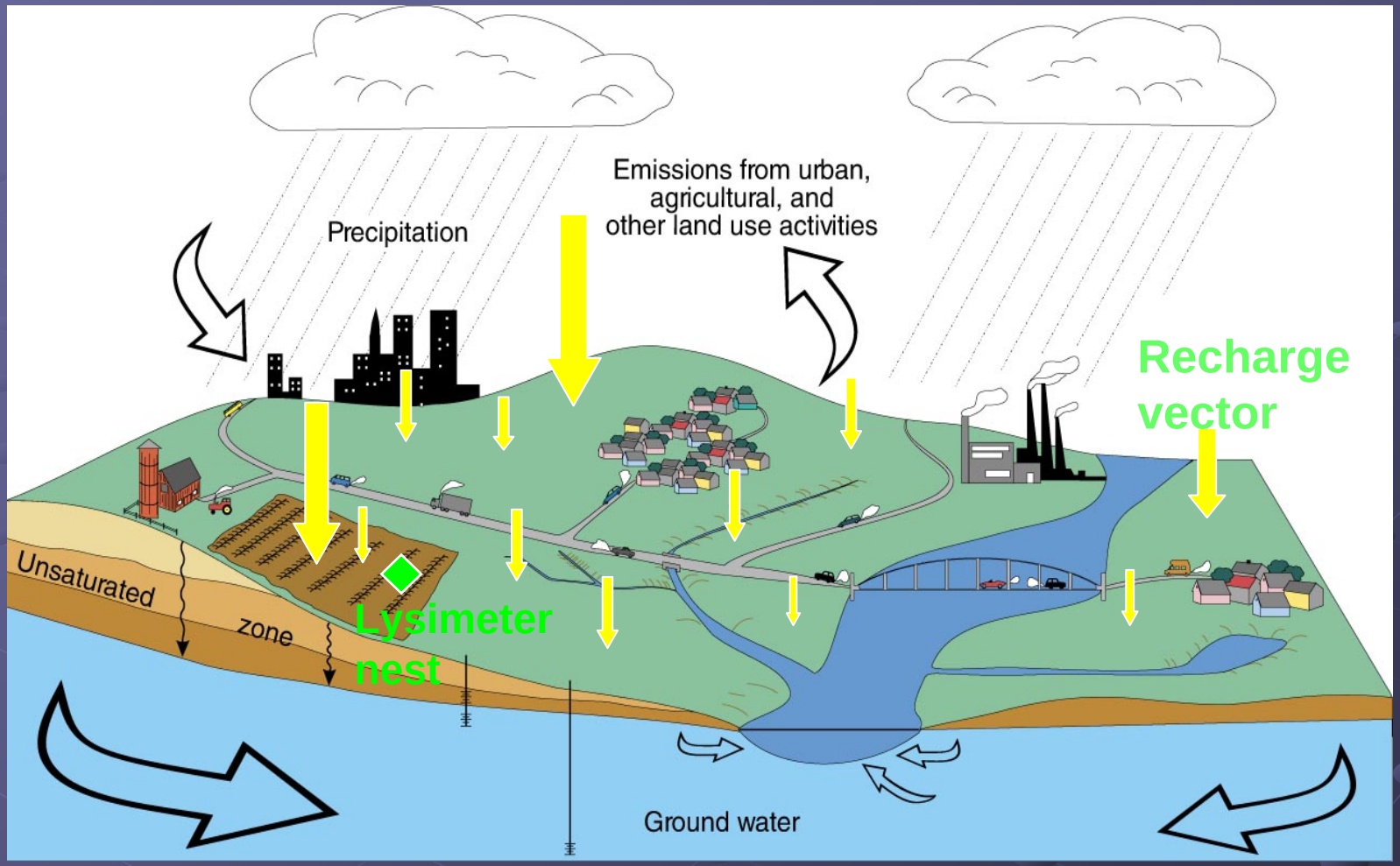
Spatial Variability ⇒ Aquifer Vulnerability



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Objective

- Develop a mobility index that classifies the potential leaching of agricultural chemicals to ground water.
  - The mobility is dependent on properties of the agricultural compounds and the soils
  - The leaching of mobile compounds to groundwater can be reduced by limiting applications before rainy months or in areas where the water table is near the surface.

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Approach

- Leaching of nutrients and pesticides to groundwater are simulated with the following considerations.
  - Agricultural practices (crop rotation and pesticides)
  - Physical and chemical properties of compounds.
  - Water Balance
  - Soil properties
- Total leaching for source areas to wells or surface water are estimated as follows:
  - Identify clusters or groups of similar soils and crops (and or rotations).
  - Construct a mechanistic model for each major cluster and run stochastically for the range of soil characteristics properties unsaturated-zone thicknesses.
  - Aerially weight the results to estimate mass fluxes for the Morgan Creek watershed.
- Final goal is to construct a mobility index specific to different hydroclimatic regions of the country.

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Morgan Creek and Weather Stations

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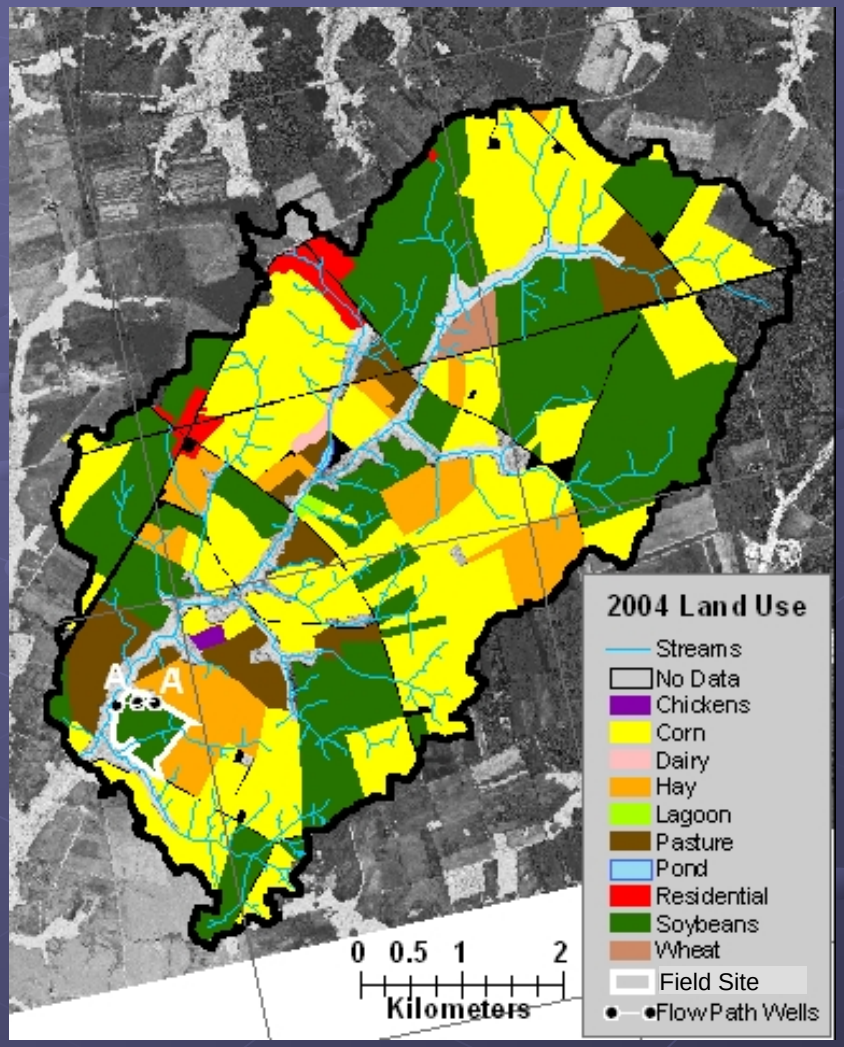
Land Use 2004



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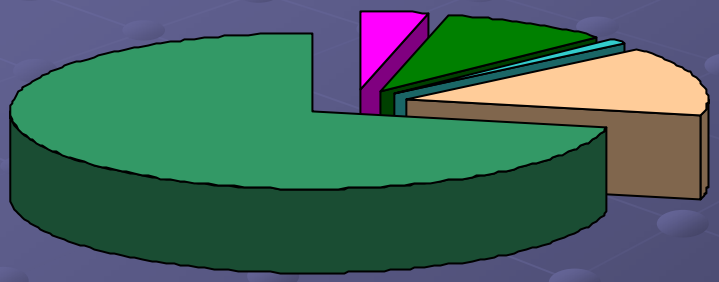
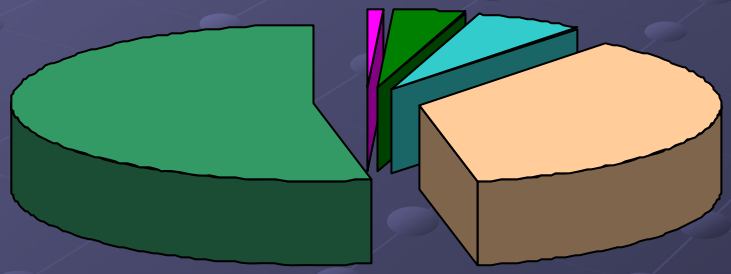
Land Use

Field Survey



NLCDE



- Rural
- Forest
- Riparian & Wetlands
- Pasture/Hay
- Crops

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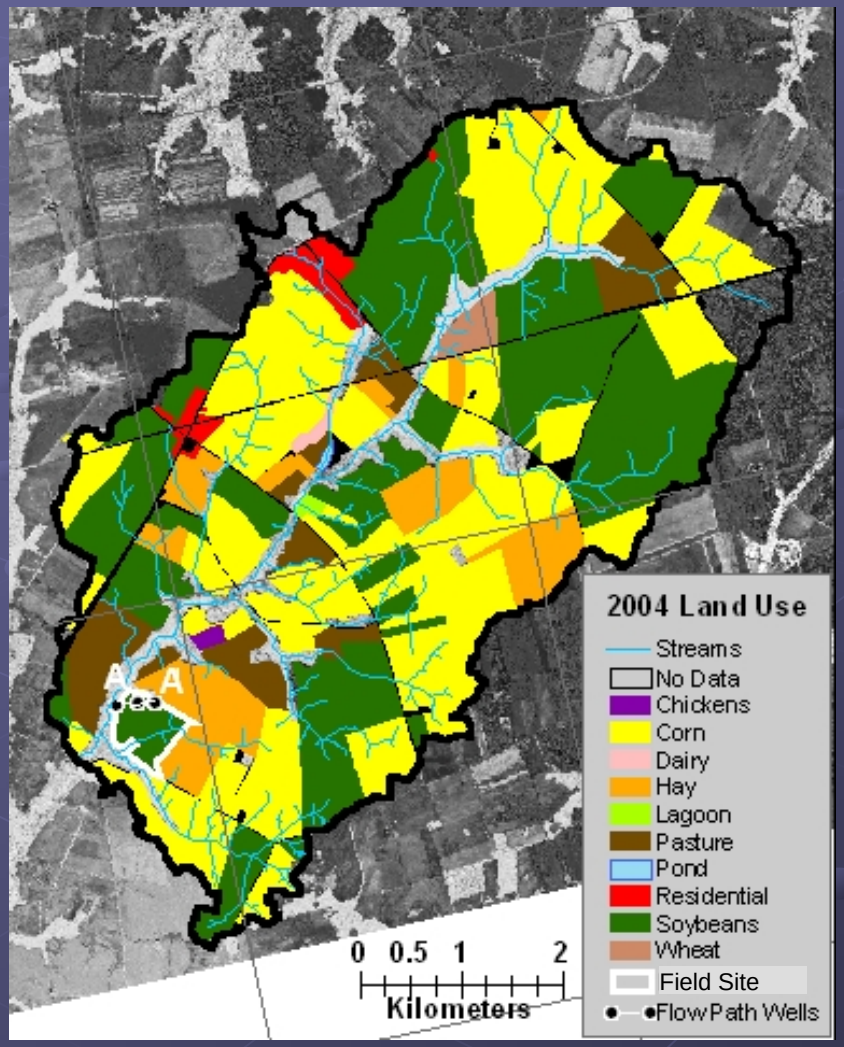
Land Use 2004



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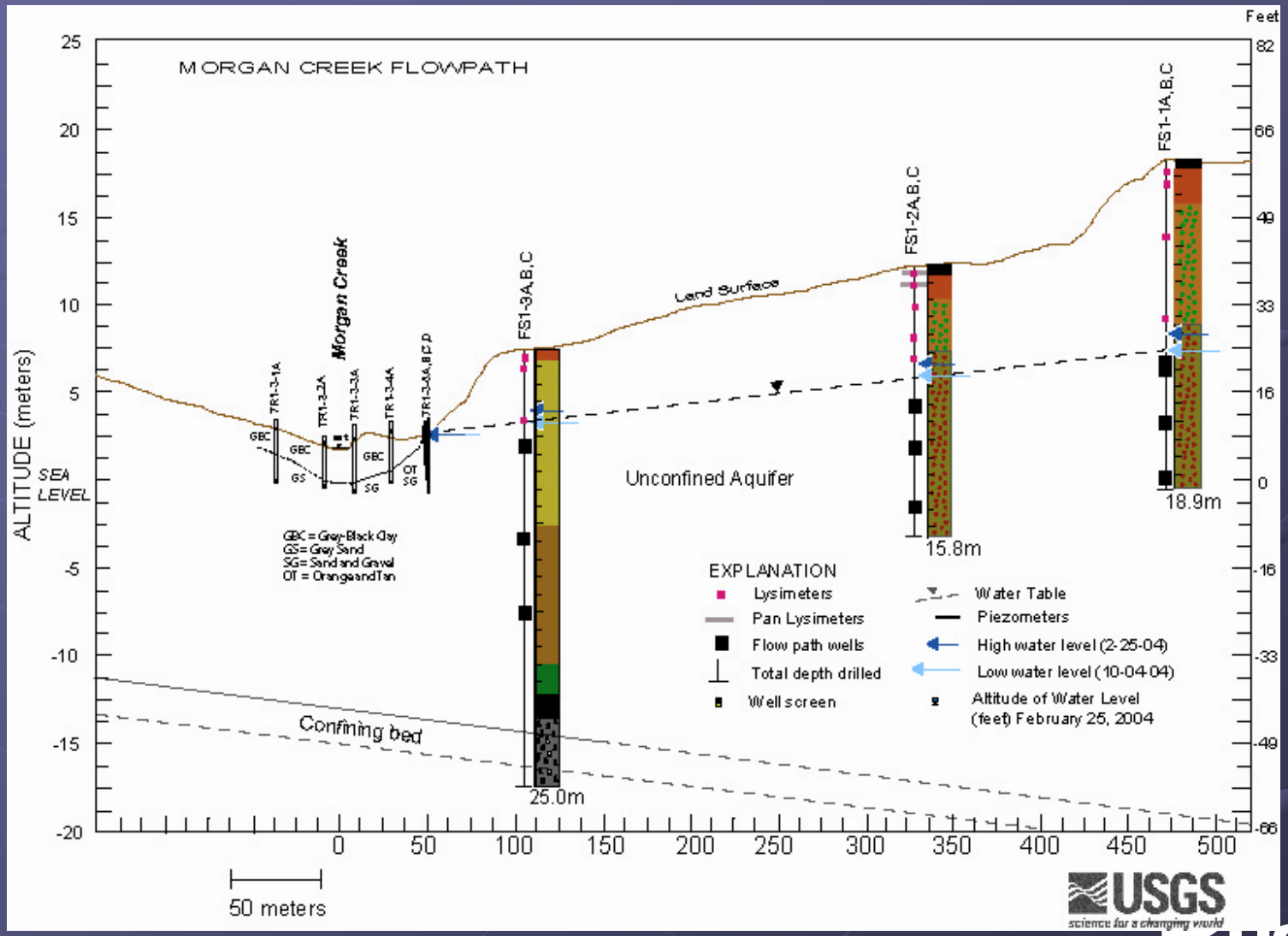
Stratigraphy and sampler locations



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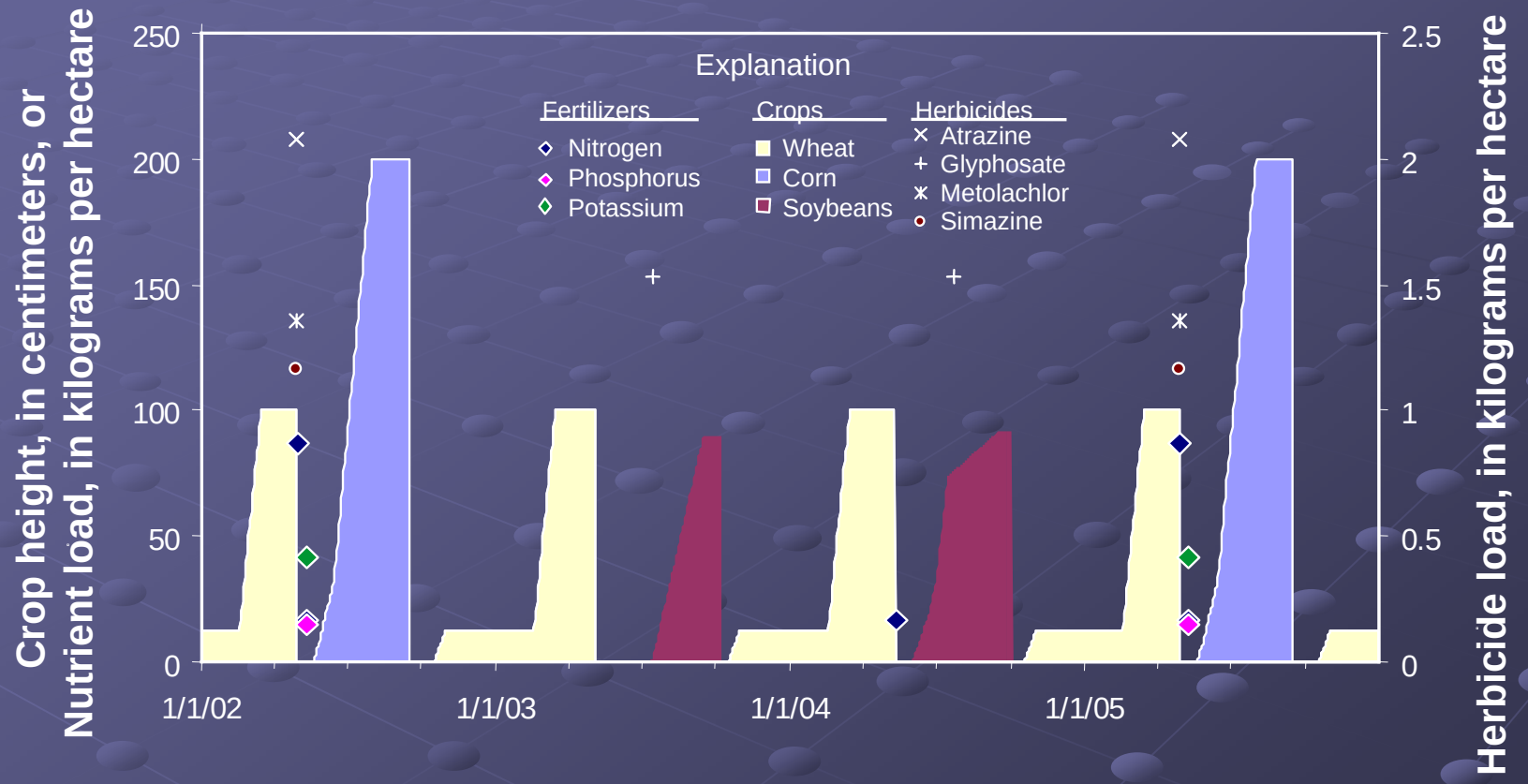
Corn-Soy-Wheat crop rotations at the Maryland field site showing timing and loads of nutrients and herbicides



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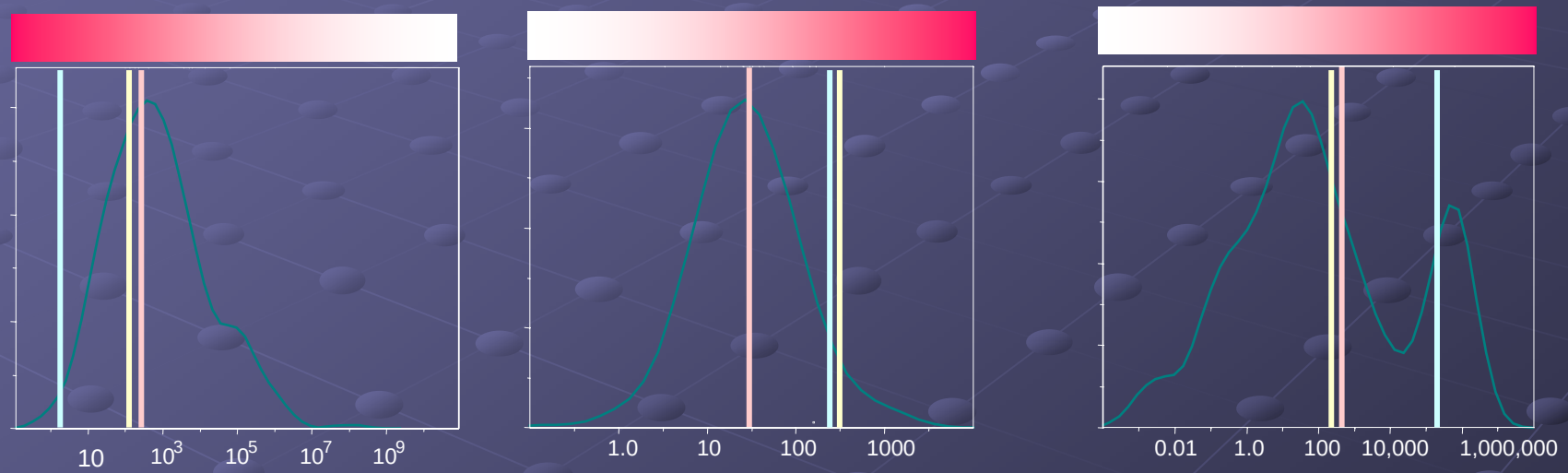
Pesticide properties

Metolachlor – Immobile

Metolachlor Ethane Sulfonic Acid (MESA) – Mobile

Metolachlor Oxanilic Acid (MOXA) – Fairly immobile



Potential groundwater risk

Lower Higher

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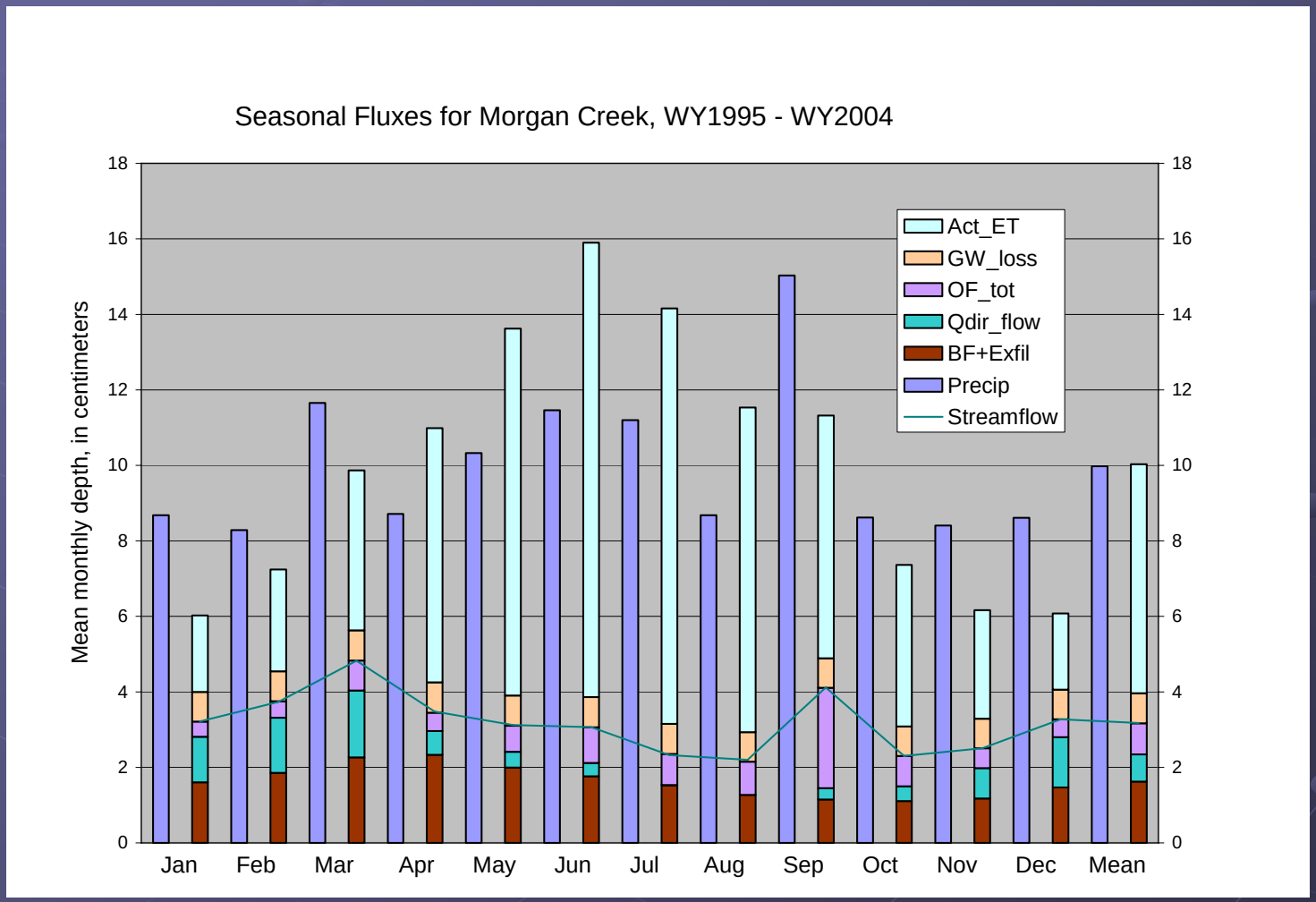
Water balance



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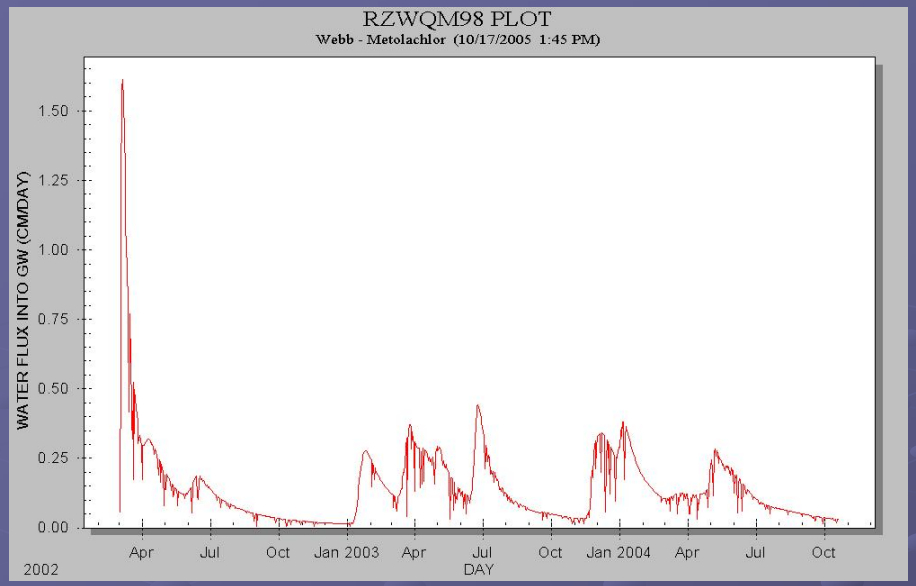

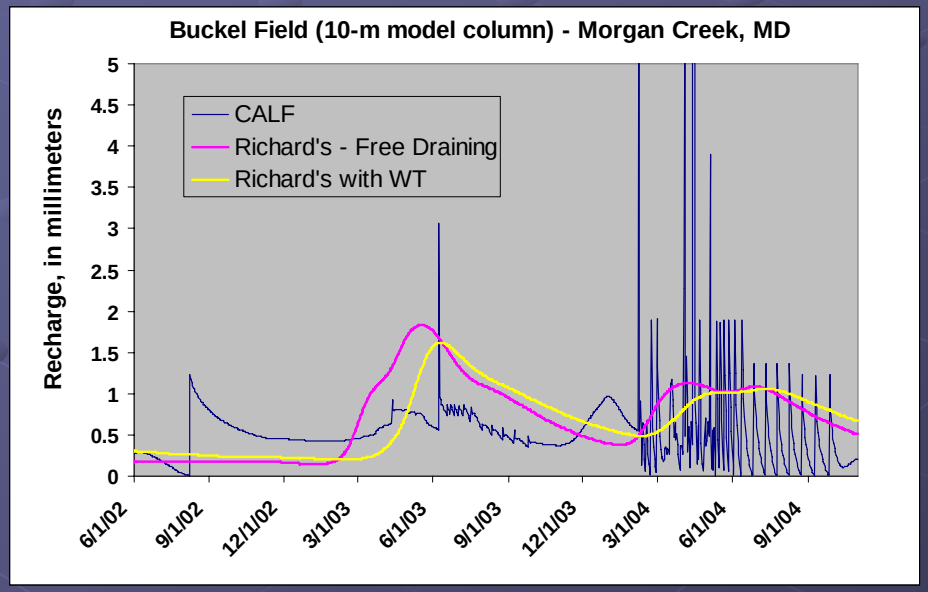

Recharge

Method	(mm/day)
WEBMOD	0.63
CALF	0.83
Richards Eqn	0.87
Darcian	0.08 – 2.95

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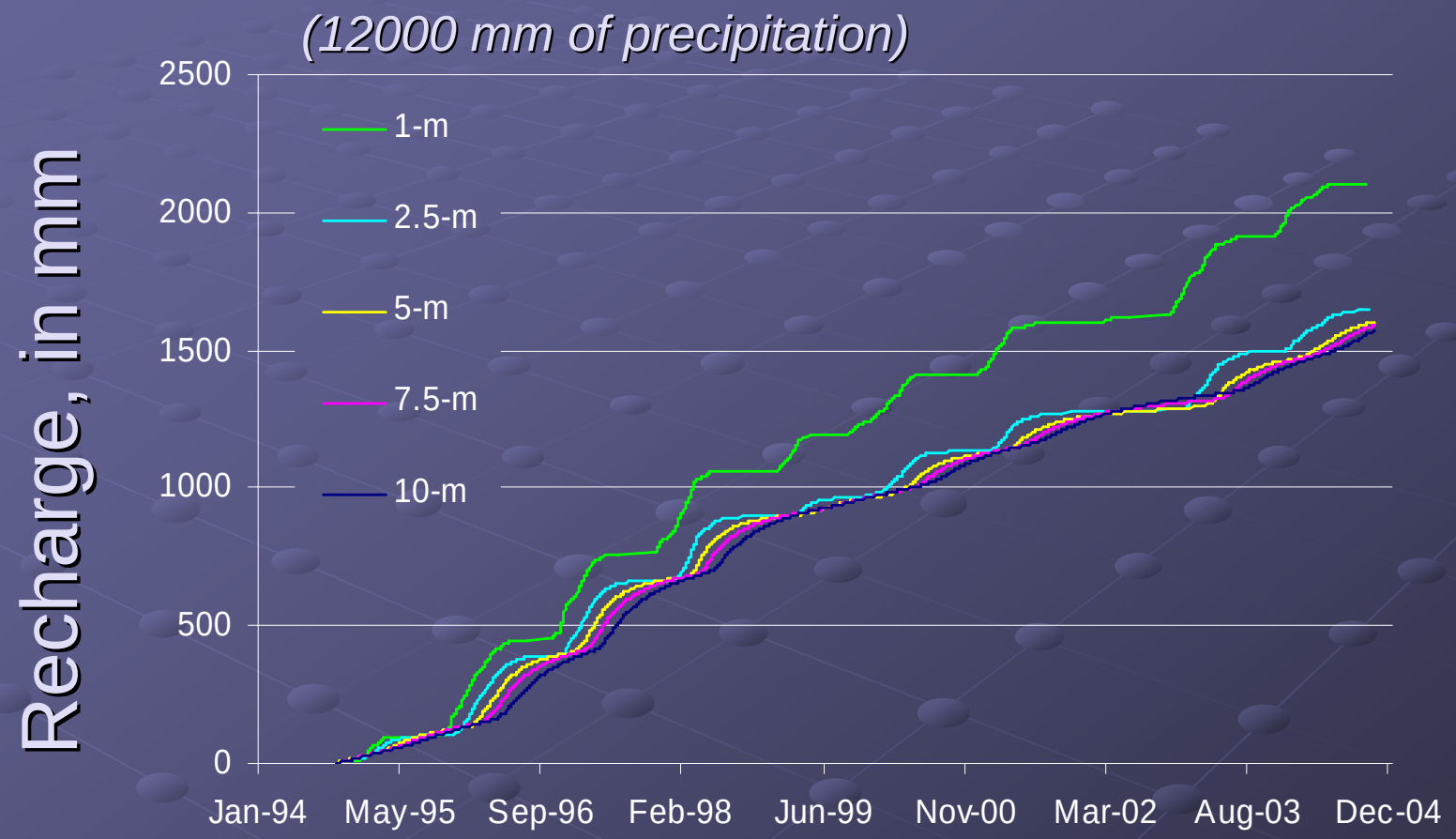
Recharge and leaching greater where the unsaturated zone is less then 2.5 meters



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Approach (General)

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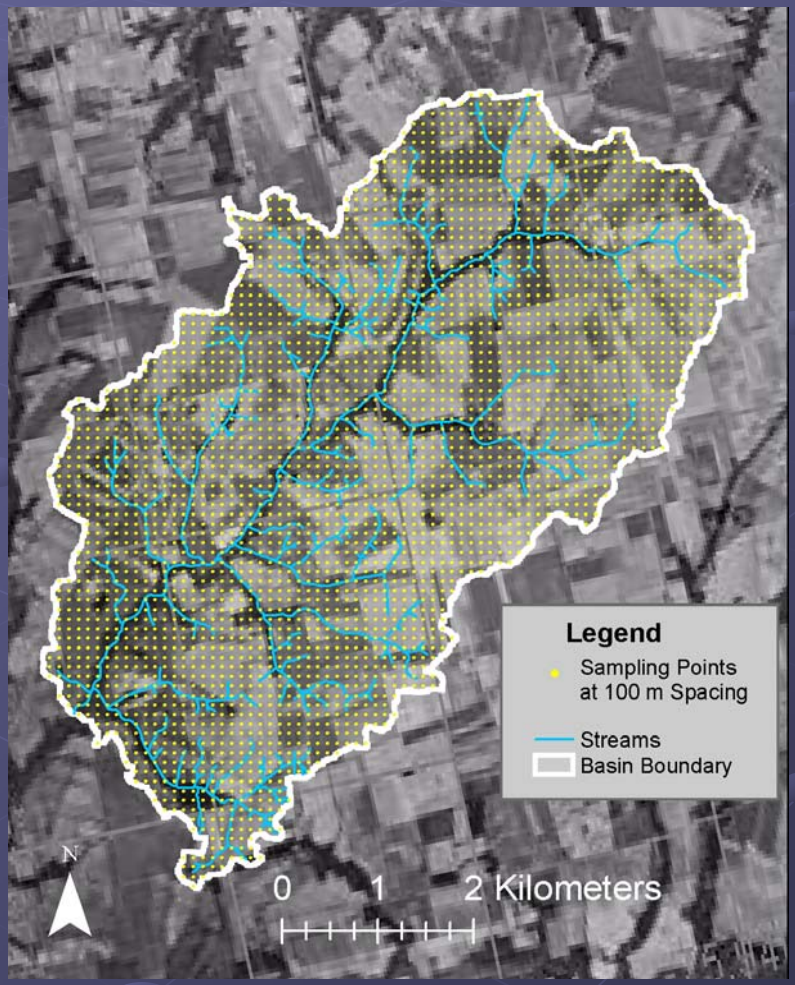
Grid sampling for crops, soils, and unsaturated zone thickness



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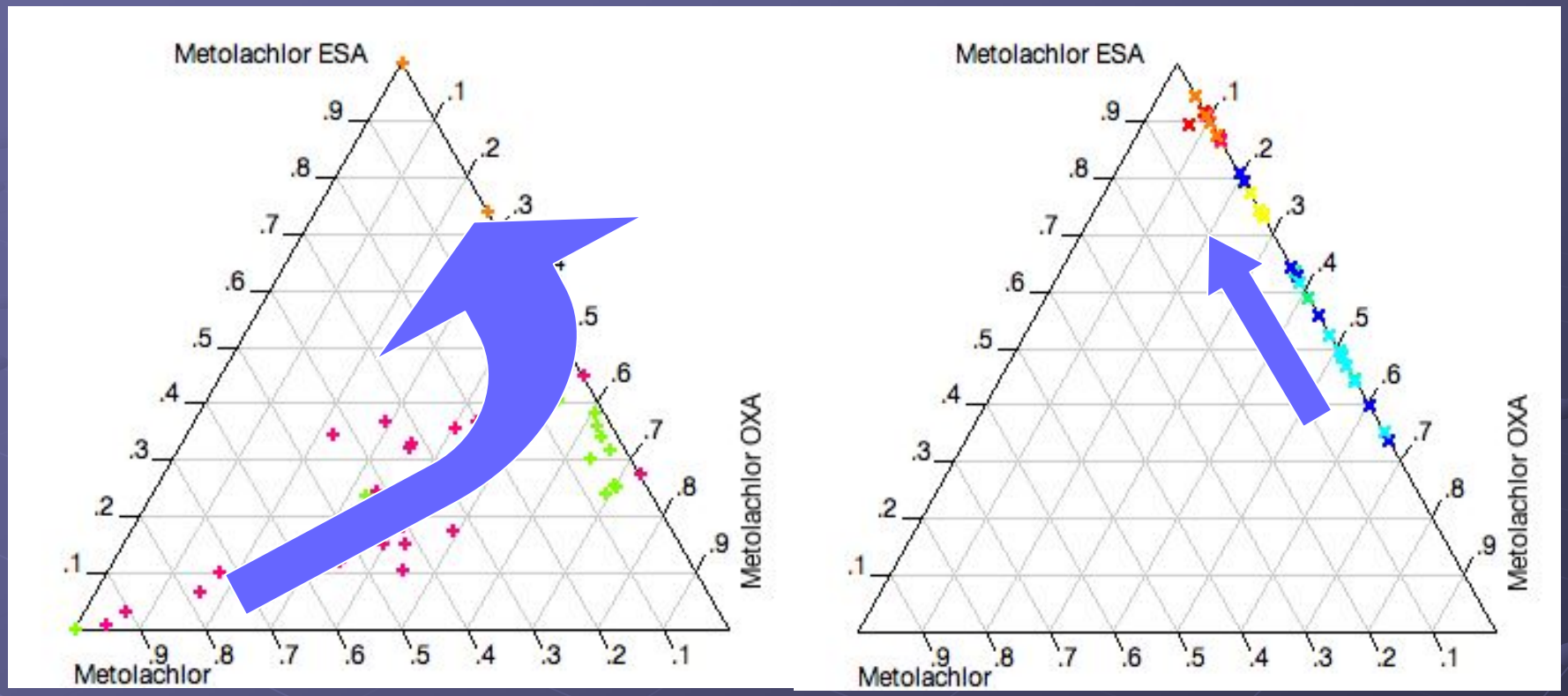
Central Nebraska

PODL



Metolachlor ESA (MESA) and Metolachlor OXA (MOXA) have longer half-lives than Metolachlor. MOXA is less mobile than MESA

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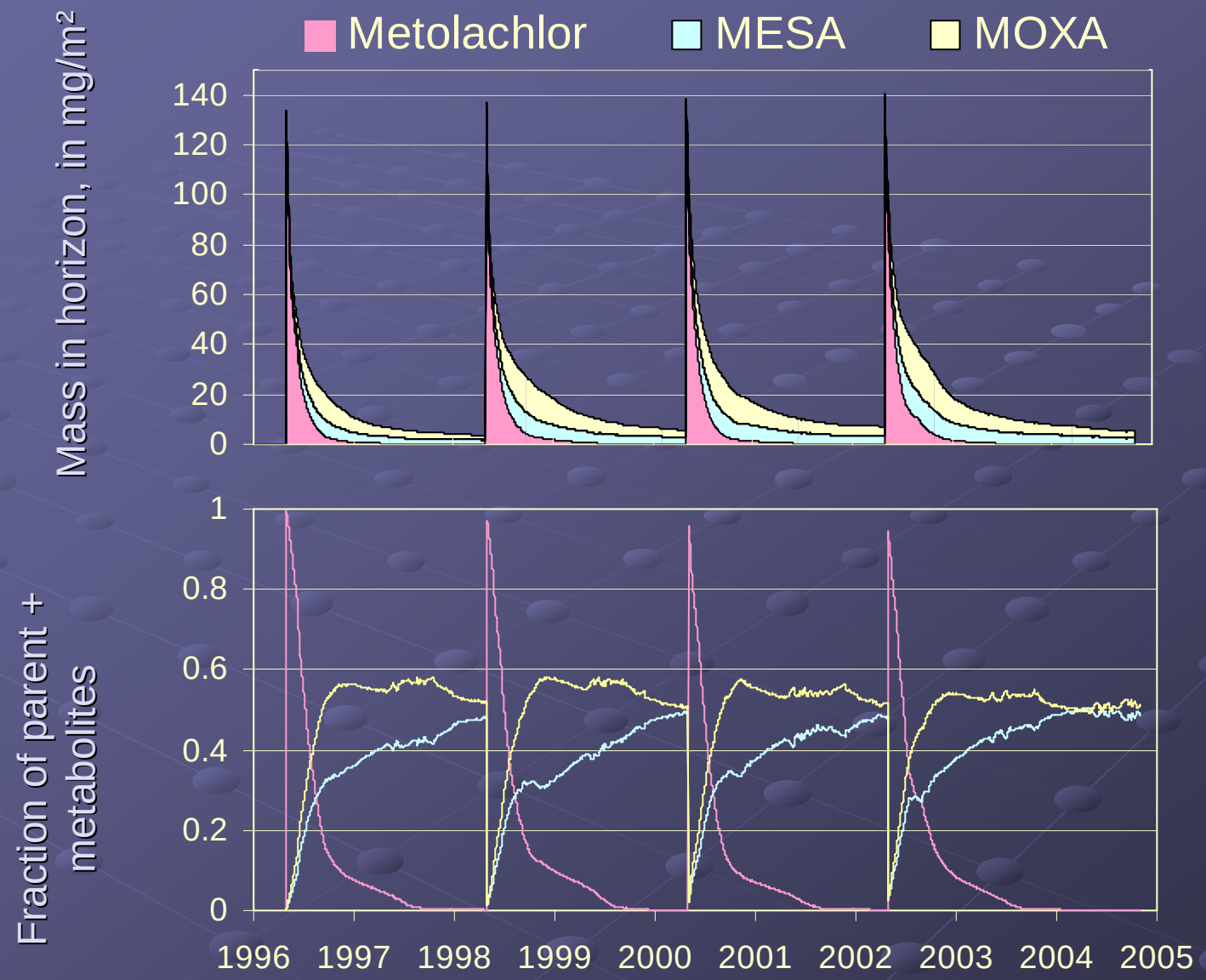
Metolachlor and metabolites in top 50cm



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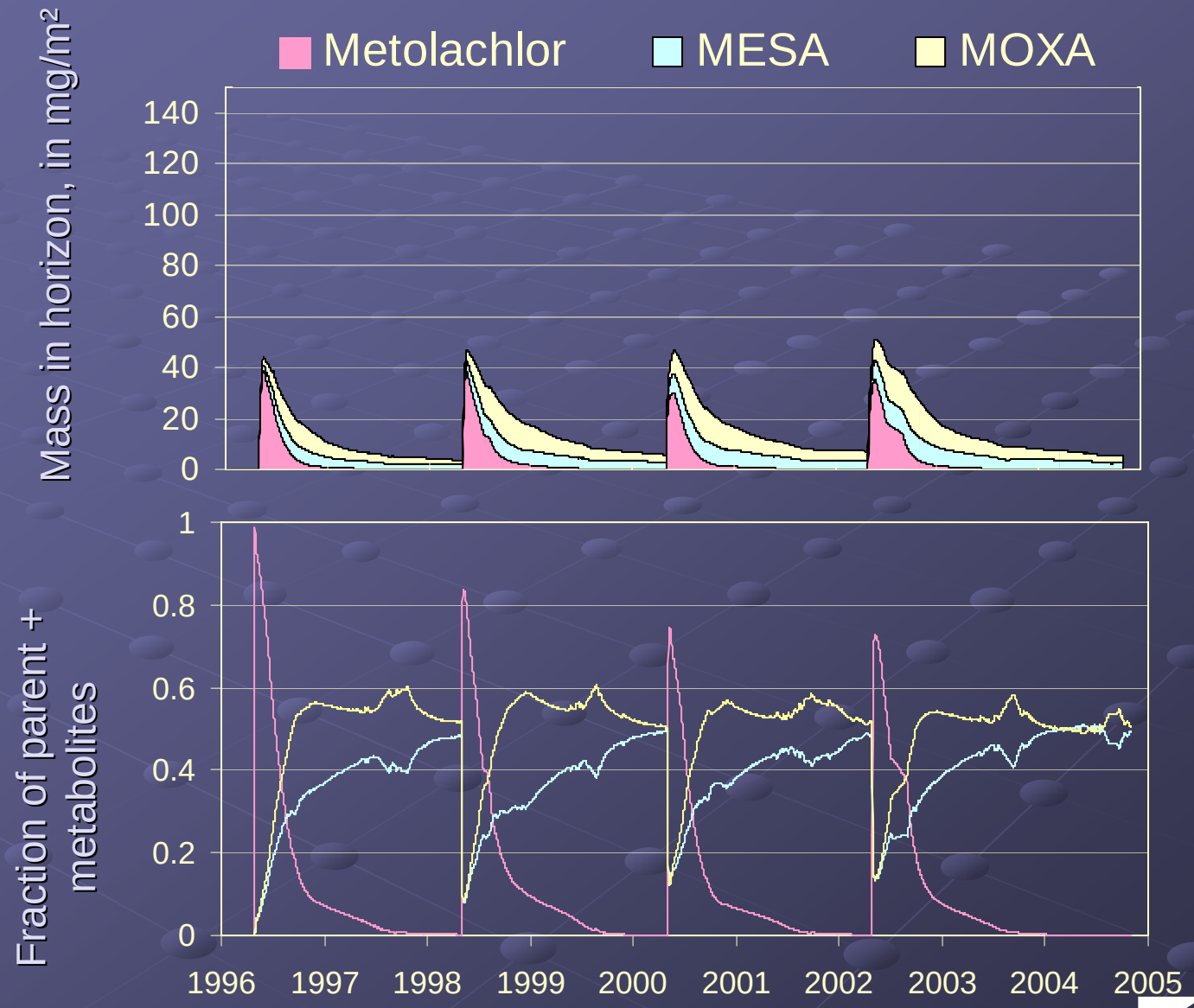
50cm – 100cm



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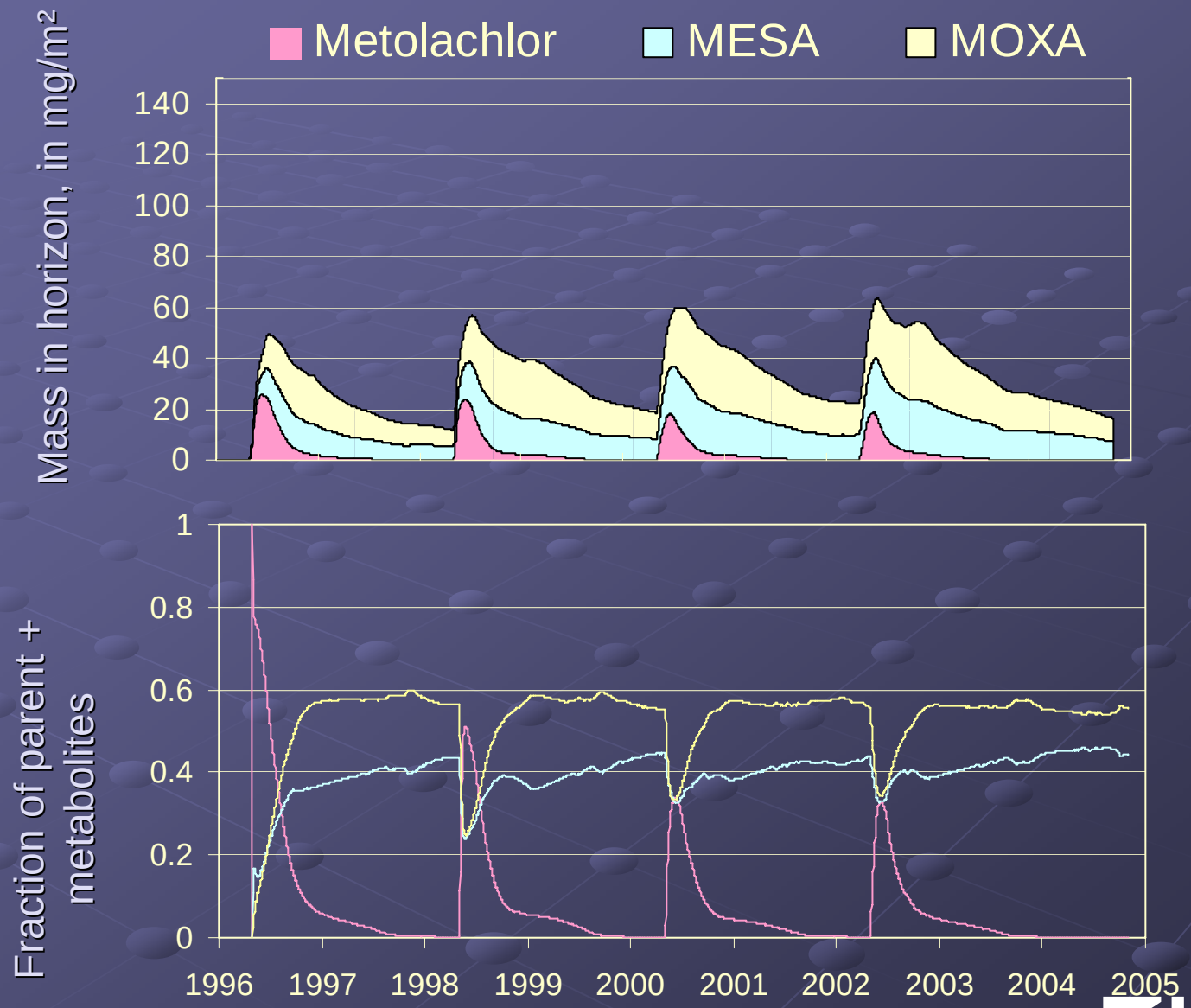
100cm – 250cm



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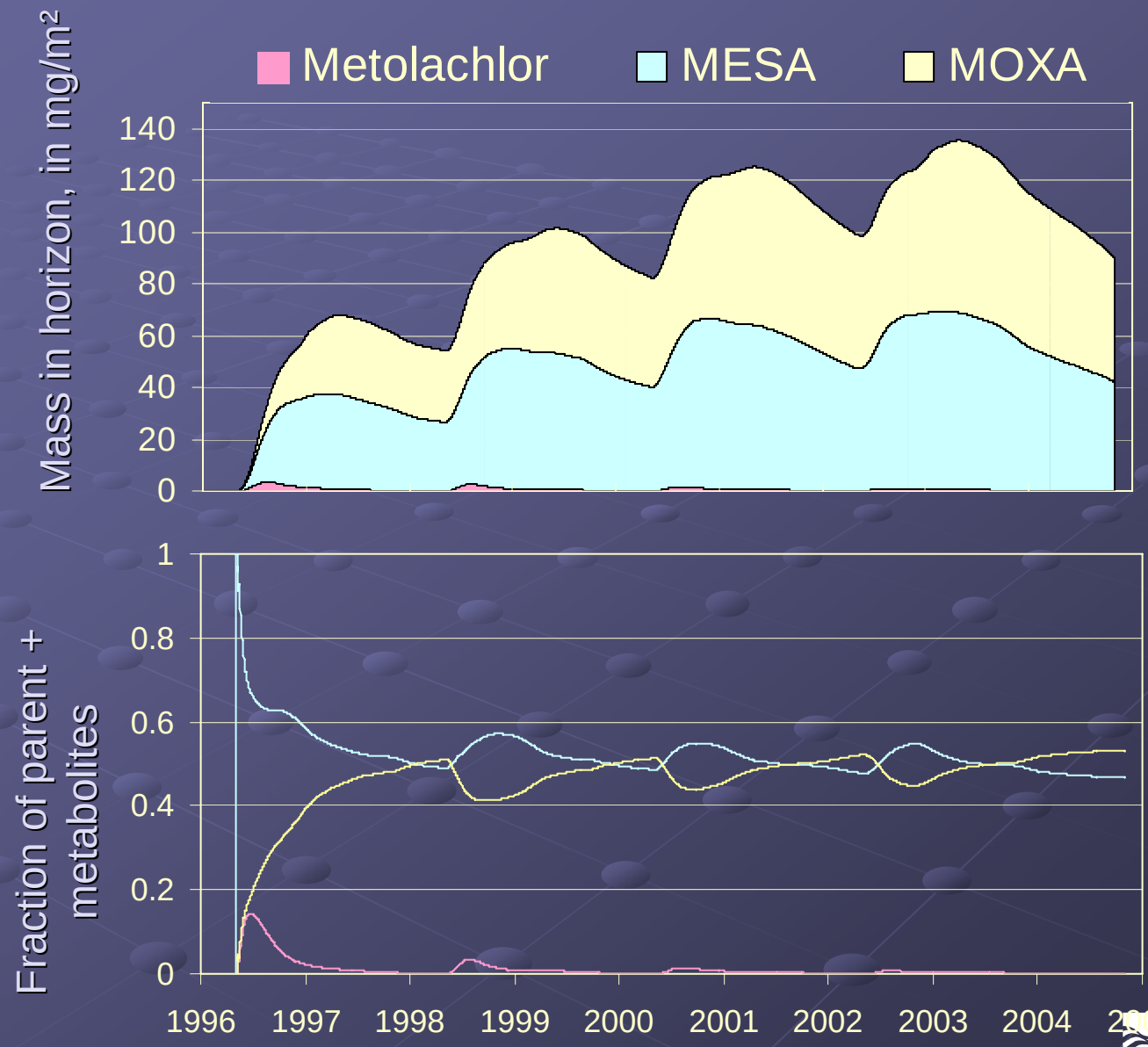
250cm – 1000cm



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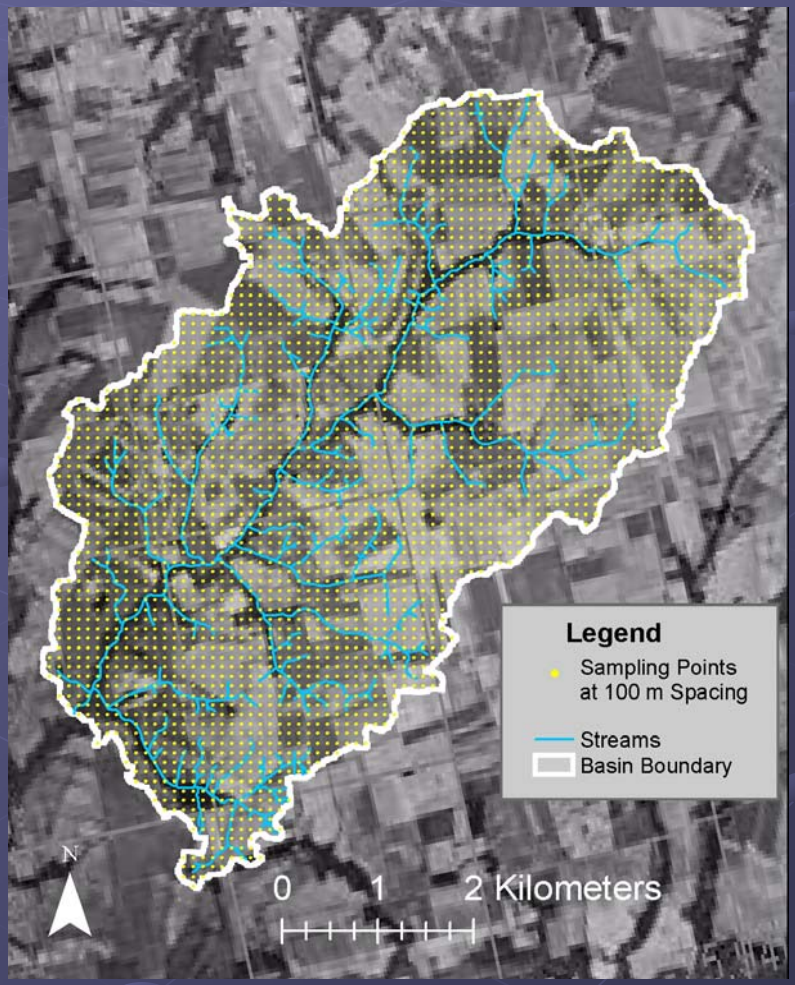
Grid sampling for crops, soils, and unsaturated zone thickness



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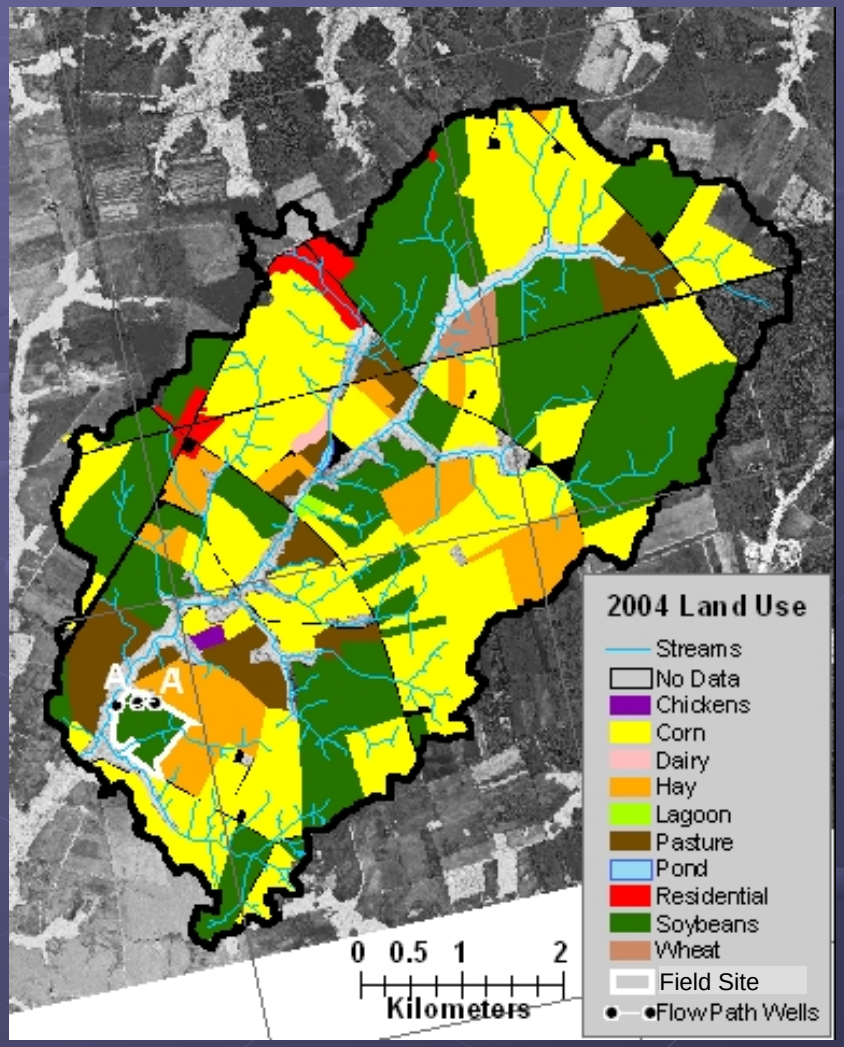
Land Use



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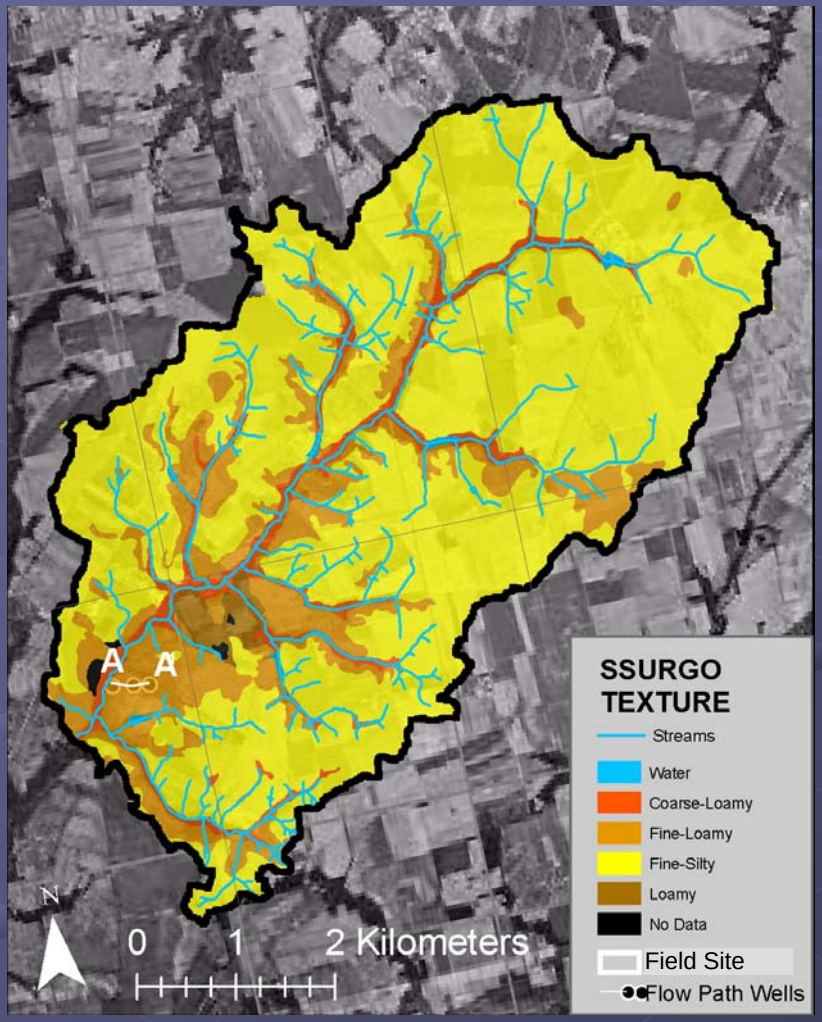
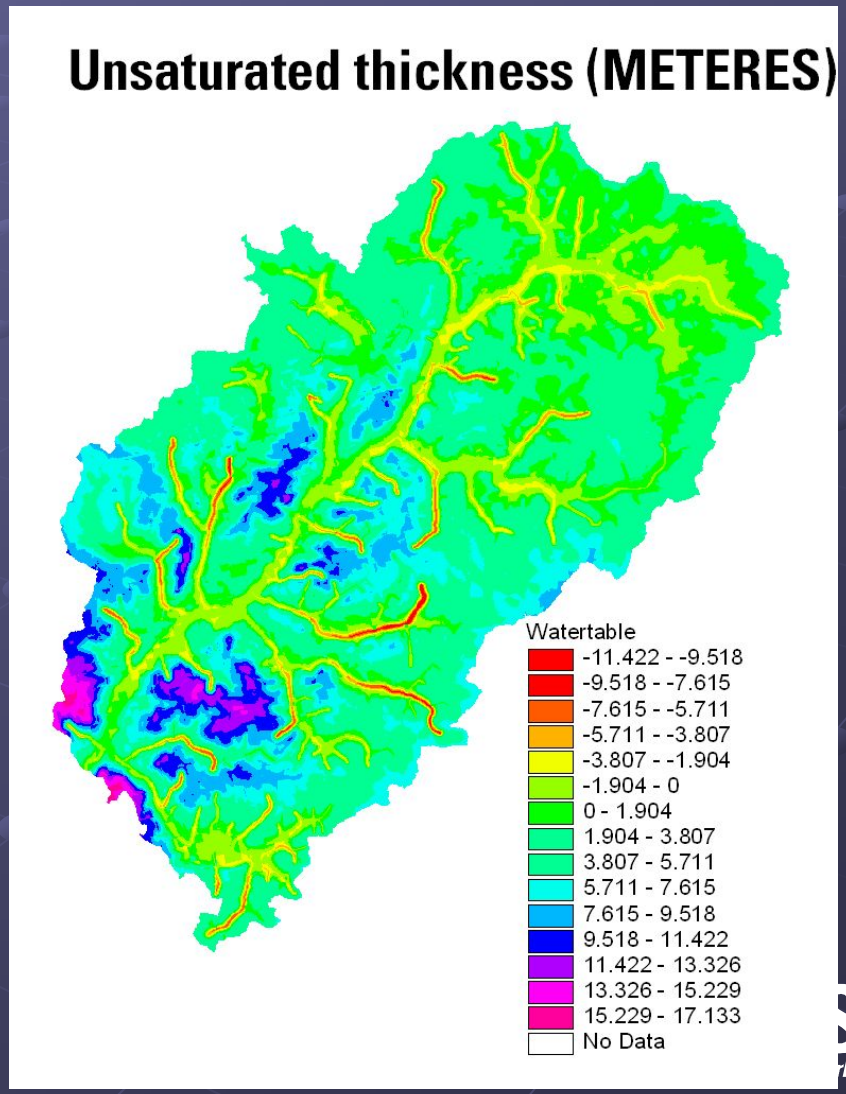
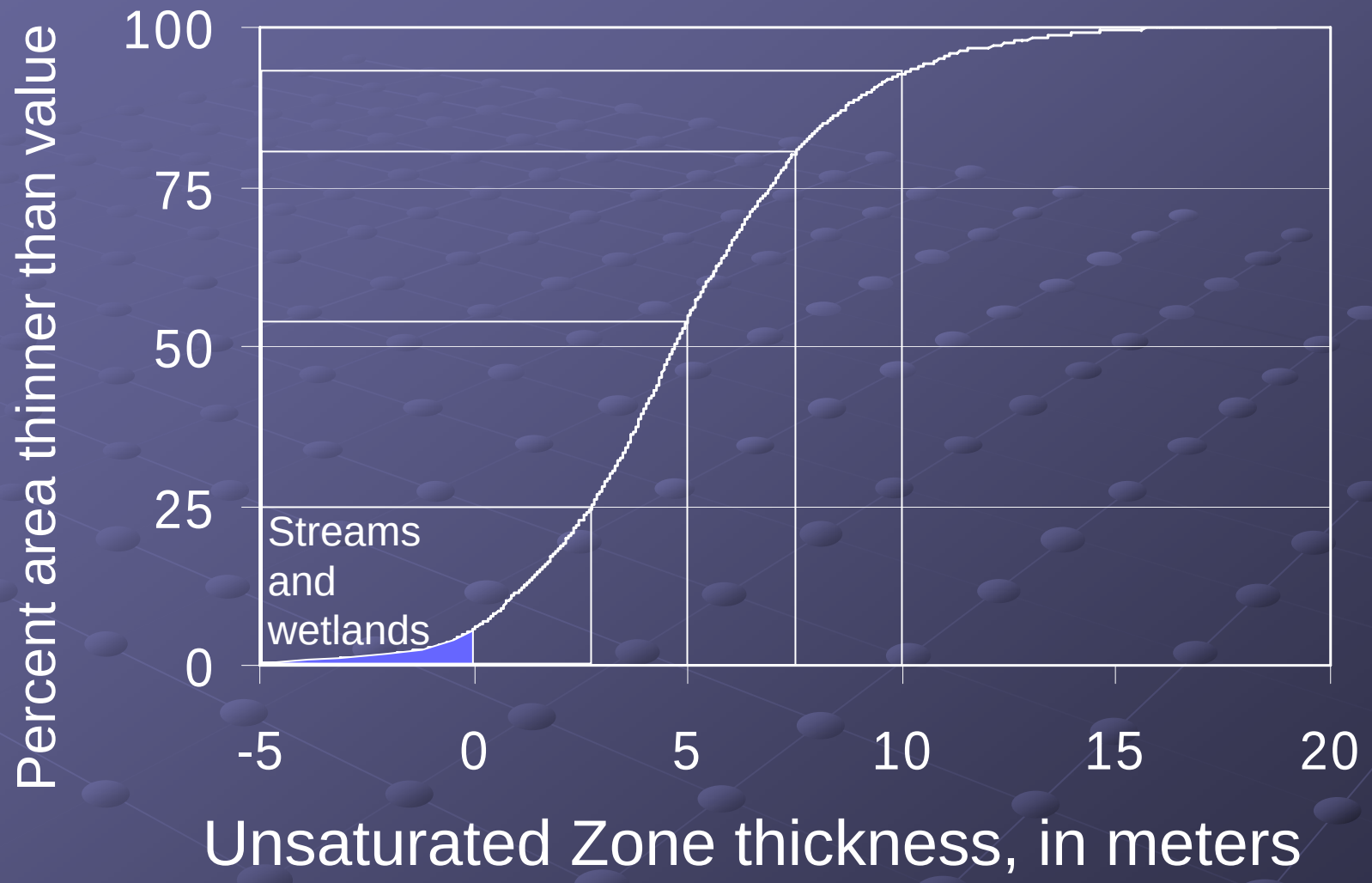
Soil Texture and Unsaturated Zone Thickness







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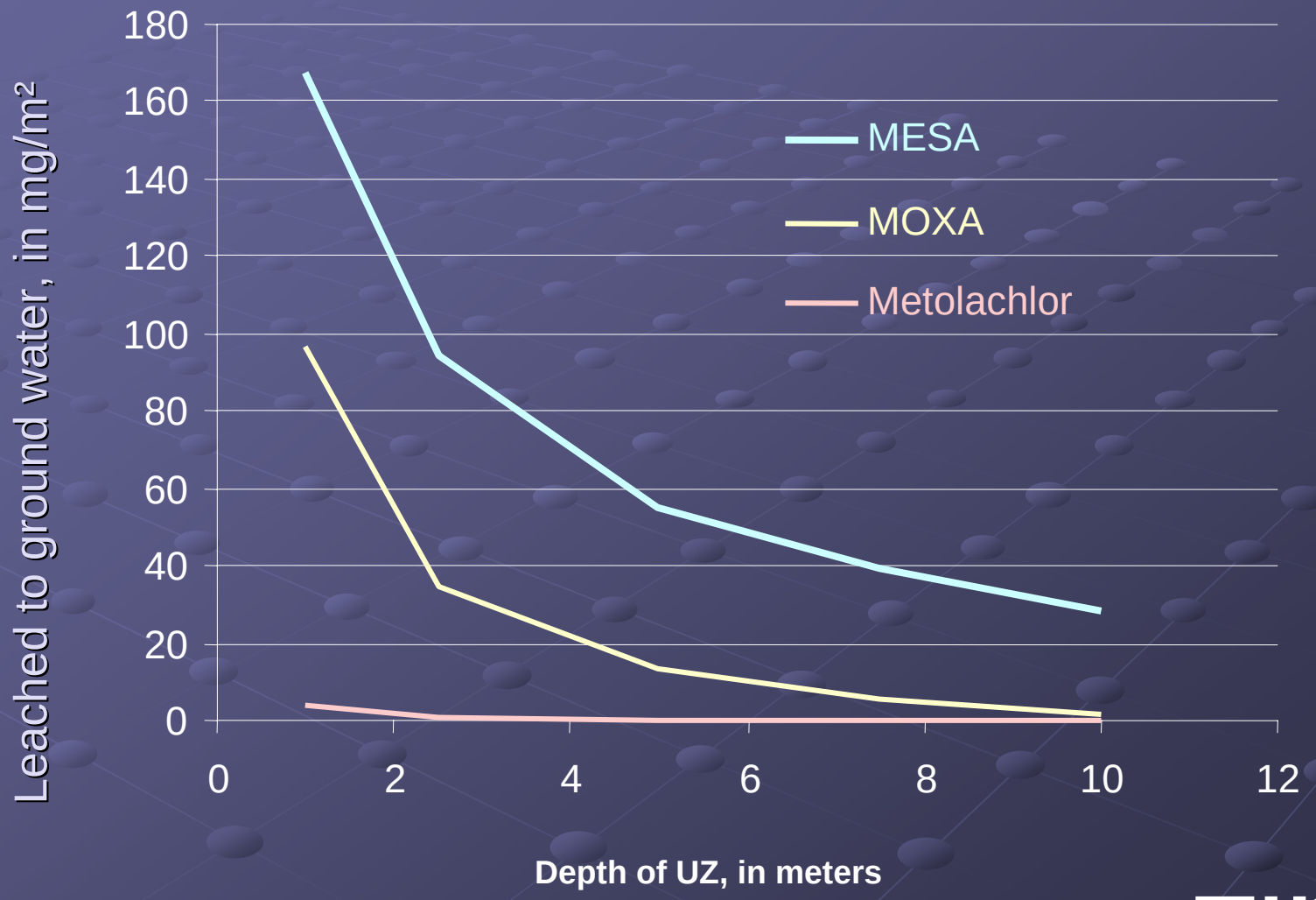
Leached after four applications of Metolachlor at 140 mg/m² (1.4 kg/ha) over 10 years; Total applied = 5.6 kg/ha



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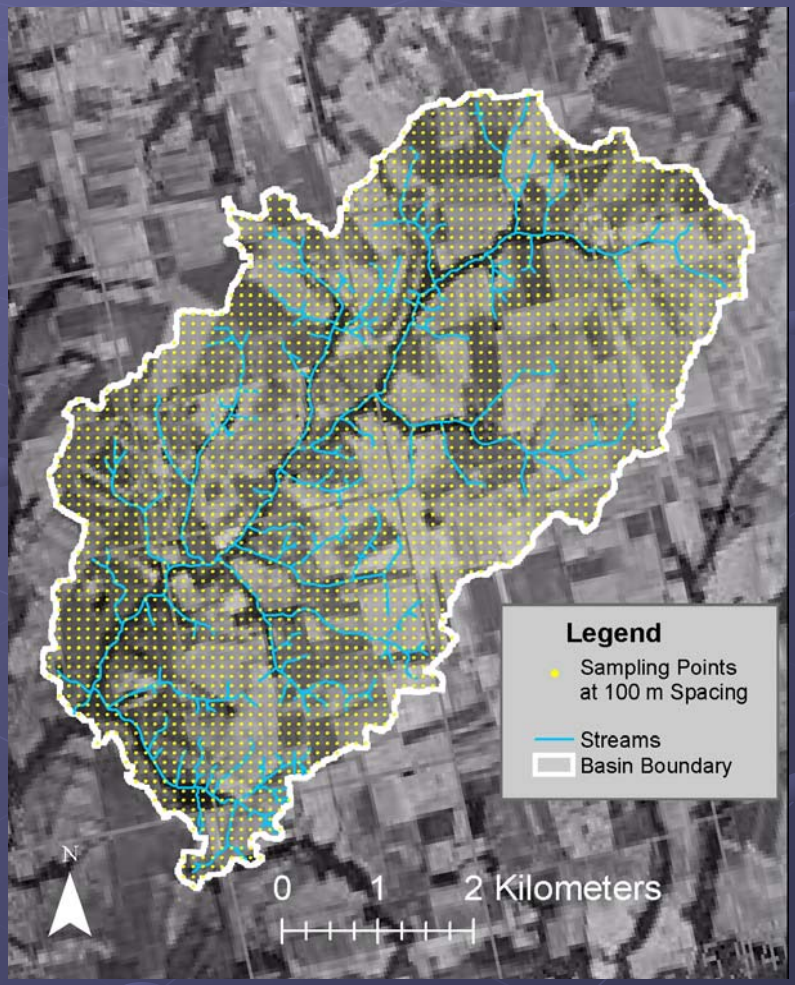

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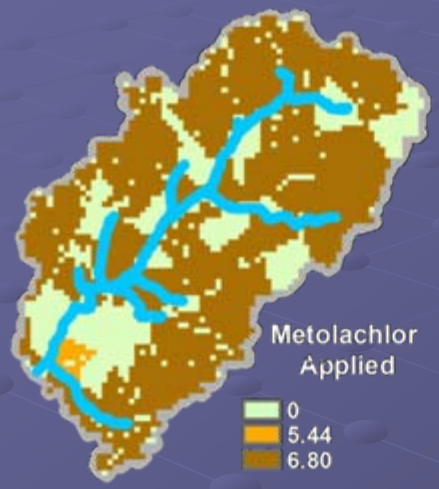
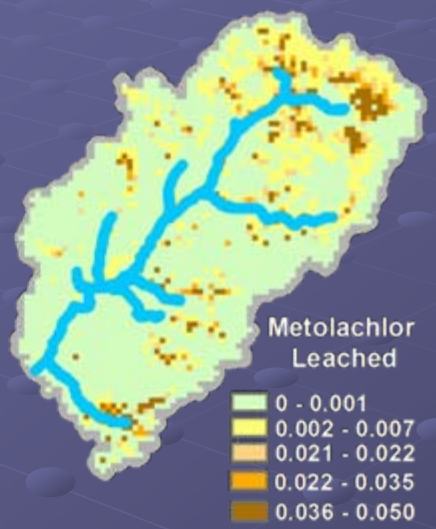
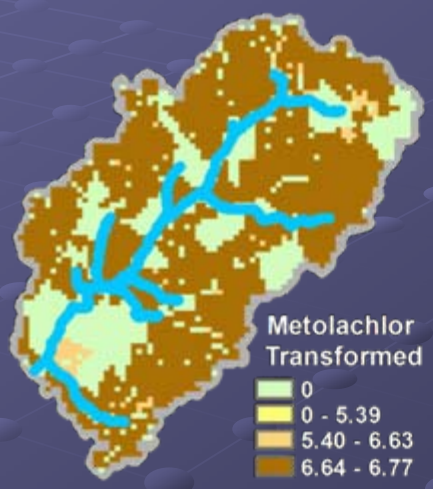
Metolachlor



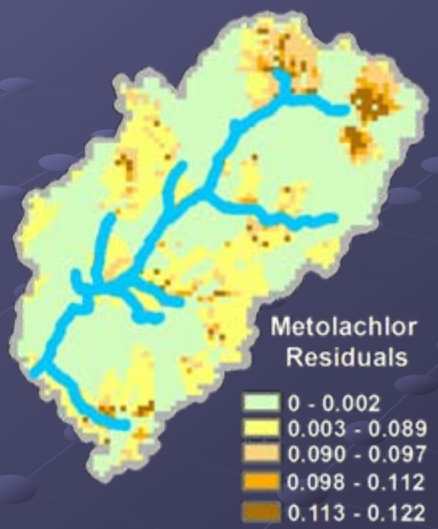
Applied



Leached



Transformed



Residual

Units are kg/ha. Five applications of Metolachlor at 1.36 kg/ha = 6.8 kg/ha

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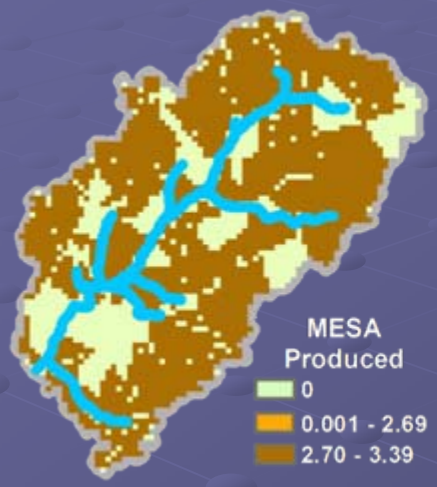
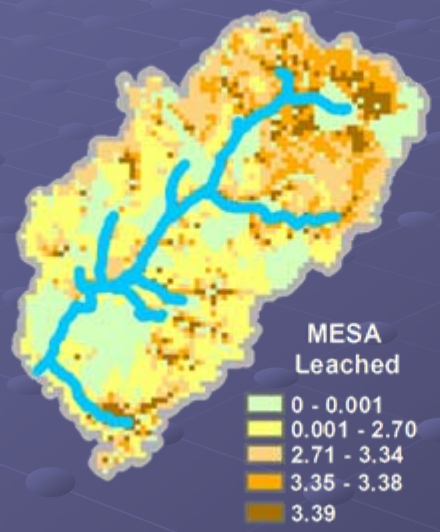
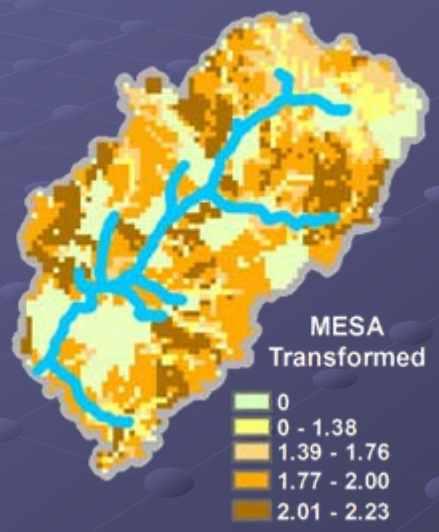
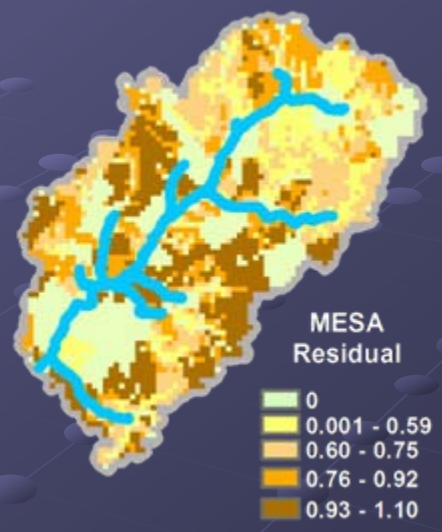
MESA









Produced Leached Degraded Residual

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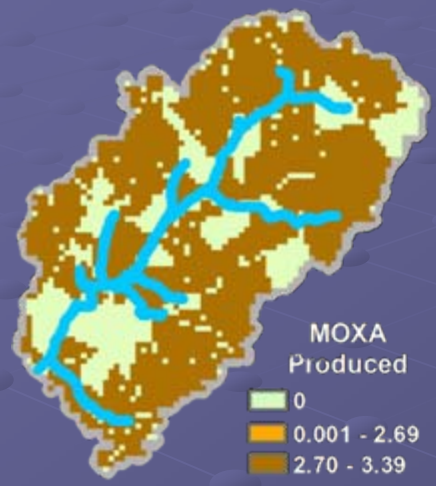
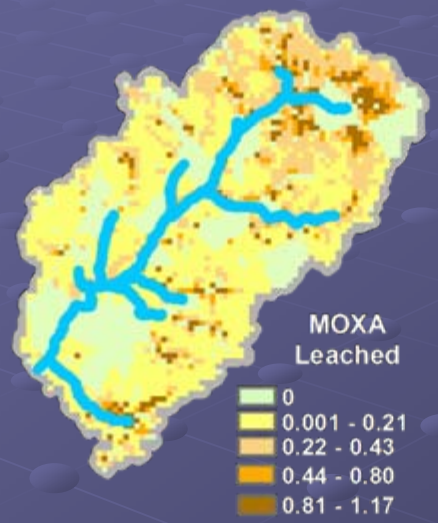
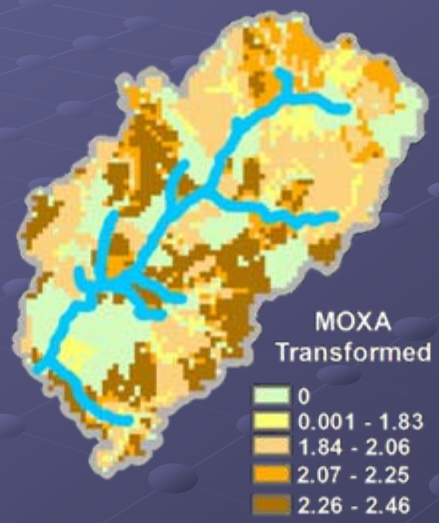
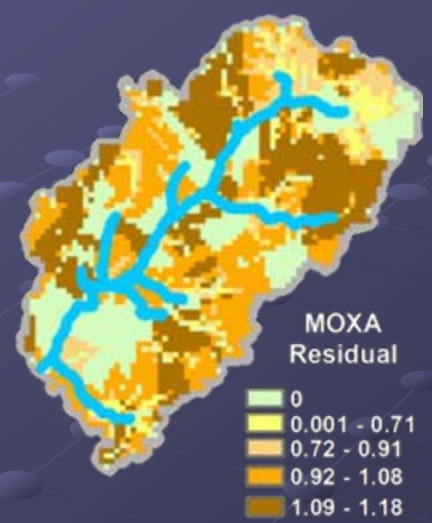
MOXA









Produced Leached Degraded Residual

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Conclusions

- The soils beneath agricultural fields provide a complex chromatographic media that can enhance or impede the leaching of agricultural chemicals to ground water.
- The soil characteristics and thickness of the unsaturated zone define the properties of the chromatographic column; The climate and agricultural management practices determine the supply rate and residence time of the agricultural chemicals.
- Conjecture: The spatial and temporal variations of agricultural chemicals delivered to ground water may be reflected in the water pumped from the water-table aquifer.

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